High Brightness LED Lighting Control

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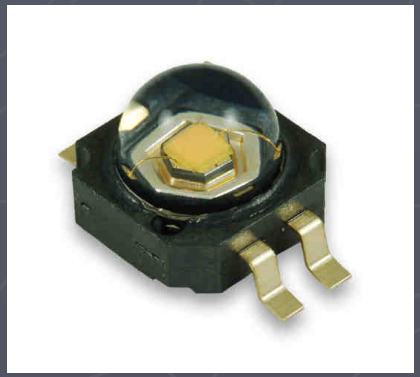
The Problem

- Current lighting sources are not as efficient as they could be
- Having to frequently replace incandescent and fluorescent bulbs

Solution

- High Brightness Light Emitting Diodes (HB LED)
  - Benefits of HB LED Lighting
    - More efficient than incandescent and fluorescent lighting
    - Ability to switch on and off at high speeds
    - Produces uniform wavelengths of light
    - Can turn on in extremely low temperatures
    - Life span up to and exceeding 50,000 hours
  - Drawbacks of HB LED Lighting
    - Increased cost of ownership
    - Operates on low voltage DC
    - Light produced is very directional
    - LEDs require a heat sink to dissipate heat



Requirements

- The LED array should provide light comparable to conventional lighting used today.
- Our lighting source must be powered by the 120 volts from a wall outlet.
- The light output of our LED array must be adjustable.
- Our LED array must be protected from over-current.
- We will compare light output, efficiency, cost, and life expectancy of all current forms of lighting with our LED array.

Considerations

- Brightness
- Efficiency
- Heat Dissipation
- Viewing Angle
- Life Span
- Cost

Luxeon K2 Emitter

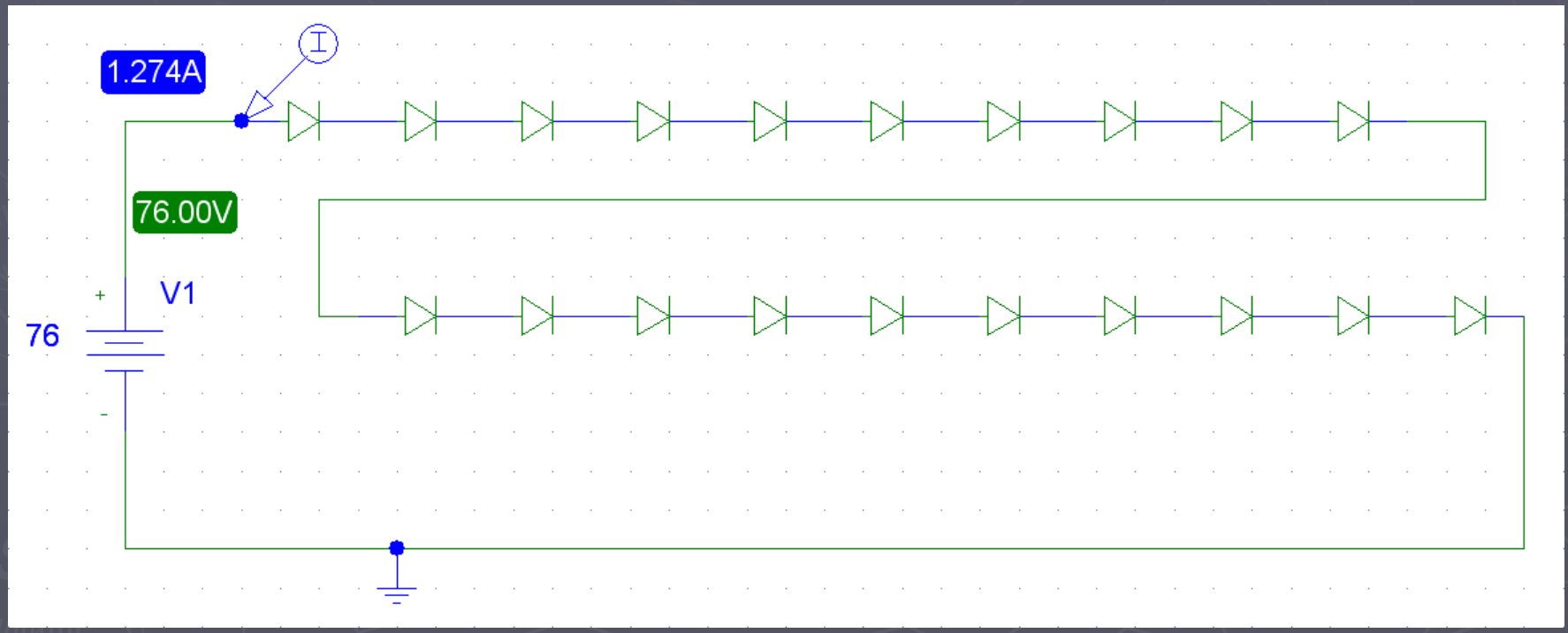
- Has a brightness of 100 lumens at one amp
  - 100 watt light bulb produces 1740 lumens
- An efficiency of 33.3 lumens per Watt
- Requires a Heat Sink.
- Viewing angle of 120 degrees
- Life span of 50,000 hours
  - 6 years running 24 hours a day
- Retails for $4.29 per LED

DESIGN

- First we needed to supply power to the LED string
- Devise a protection scheme for the LEDs
- Write PIC code to generate a variable duty cycle square wave, and provide indication
- Provide power to operate PIC

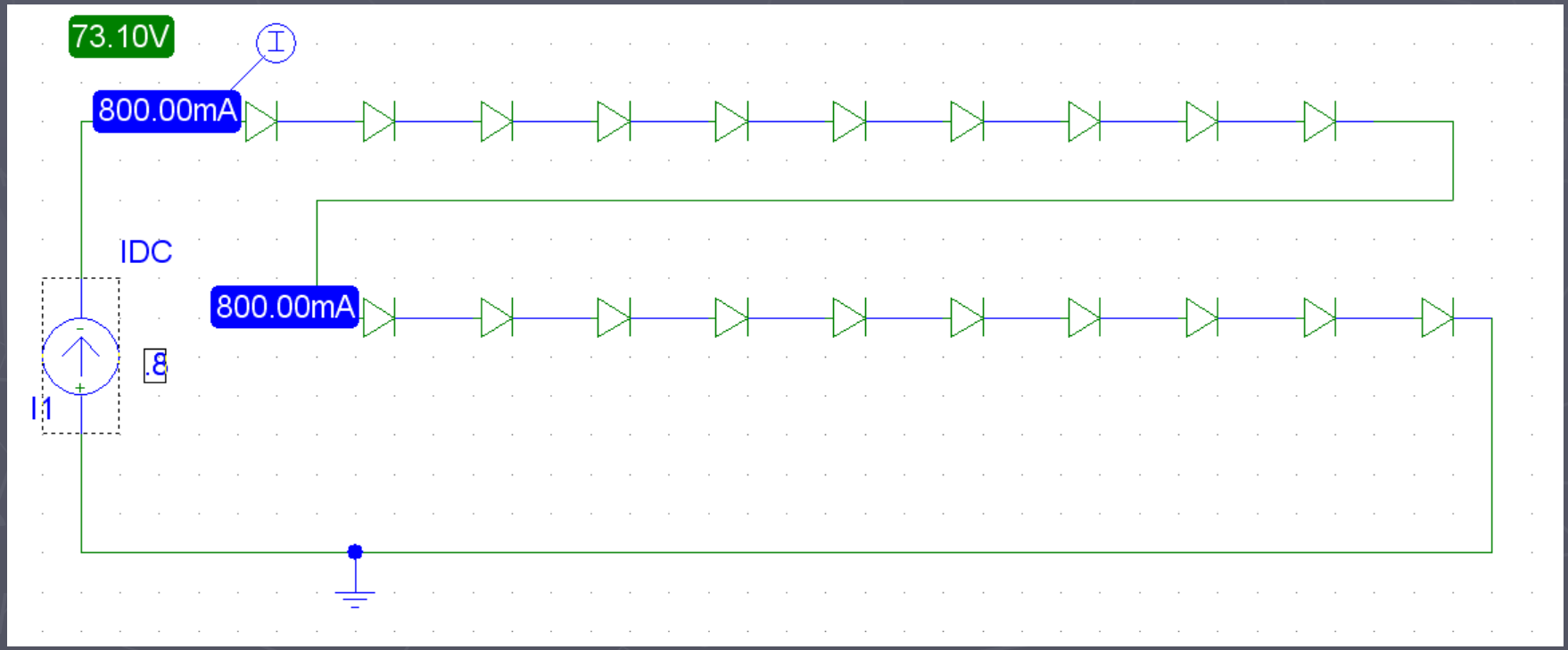
Voltage Control

- Controlling the voltage to achieve exactly 500mA
- A change of 3 volts results in a change of one amp is sensitive



Current Control

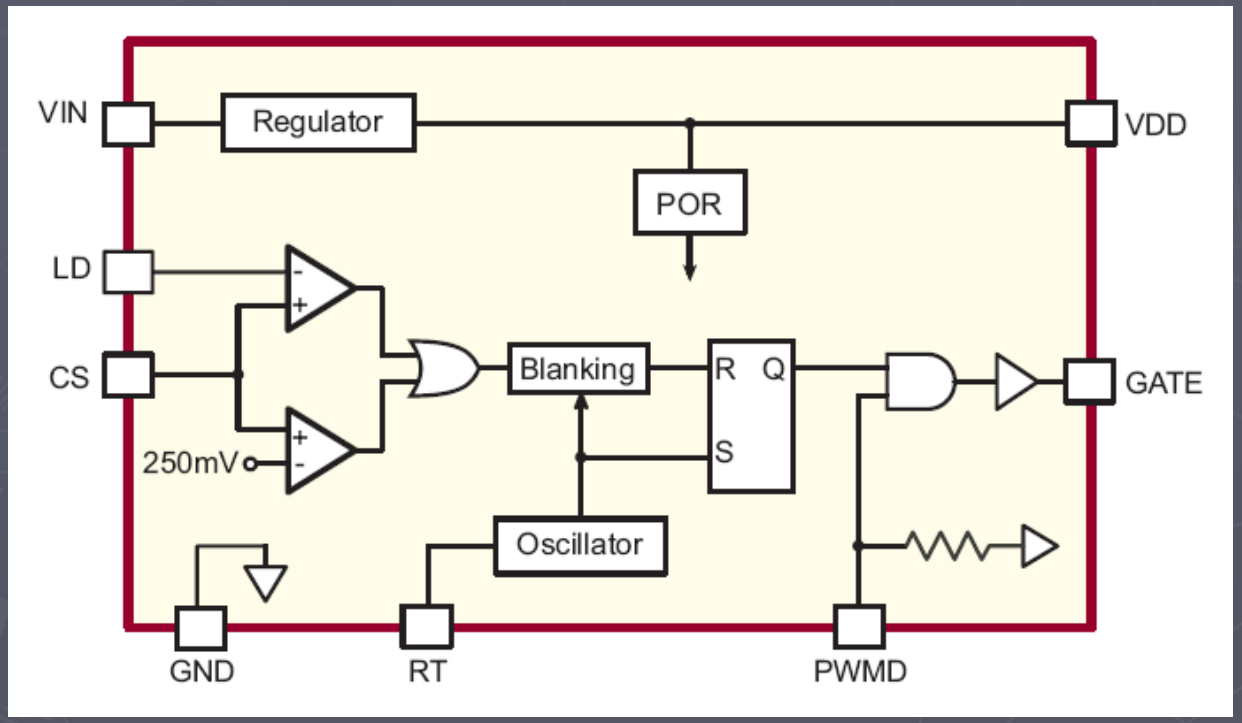
- Controlling the current allows for more precise control



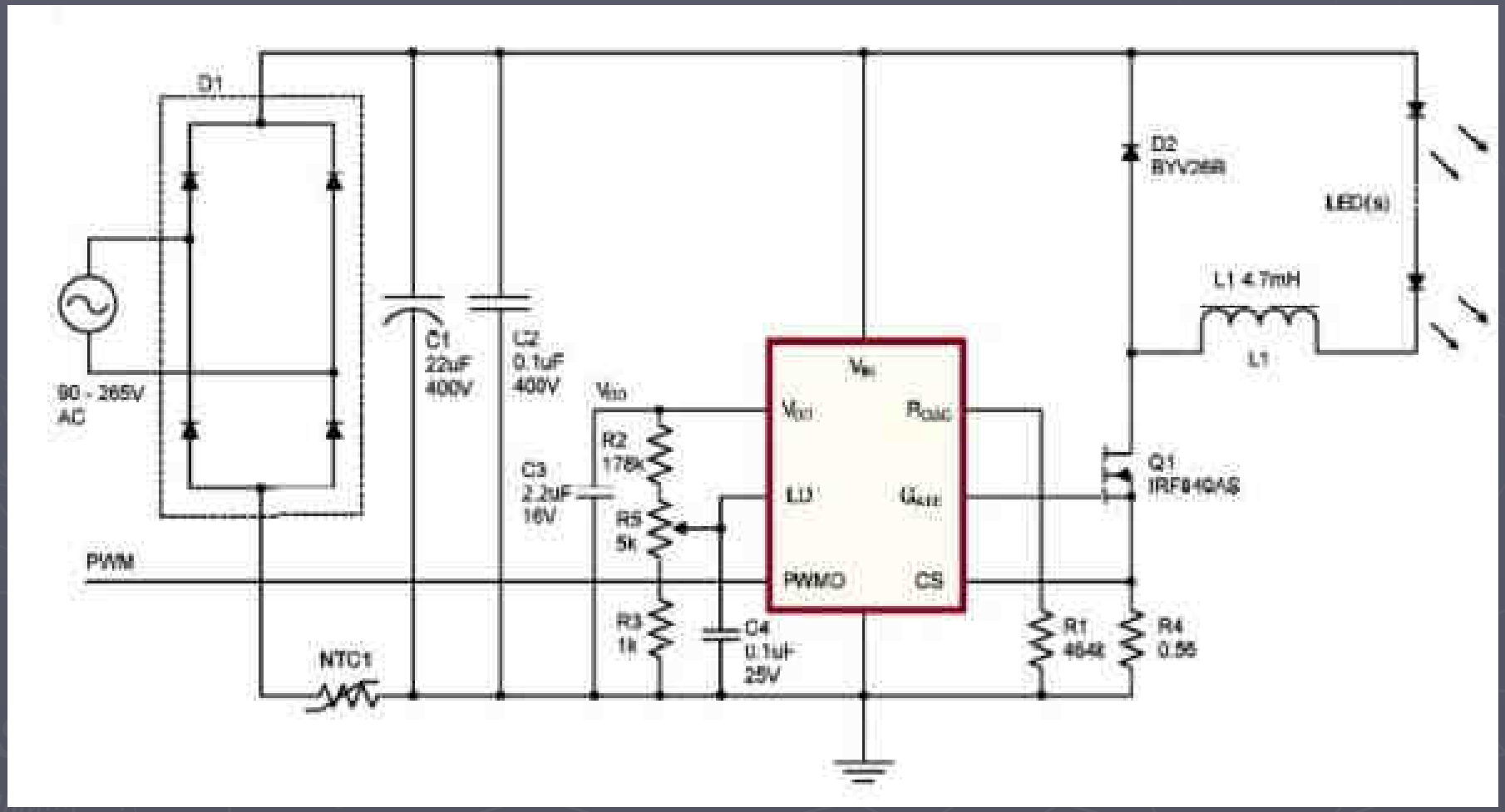
HV9910B

- An open loop current mode control HBLED driver IC
- Provides over current protection using sense resistor and comparator logic
- Allows use of Pulse Width Modulation to control LED output current
- Accepts input voltages between 8 to 450VDC
- Maximum output current of 1.5 amps
- Maximum output voltage of .5*Vin

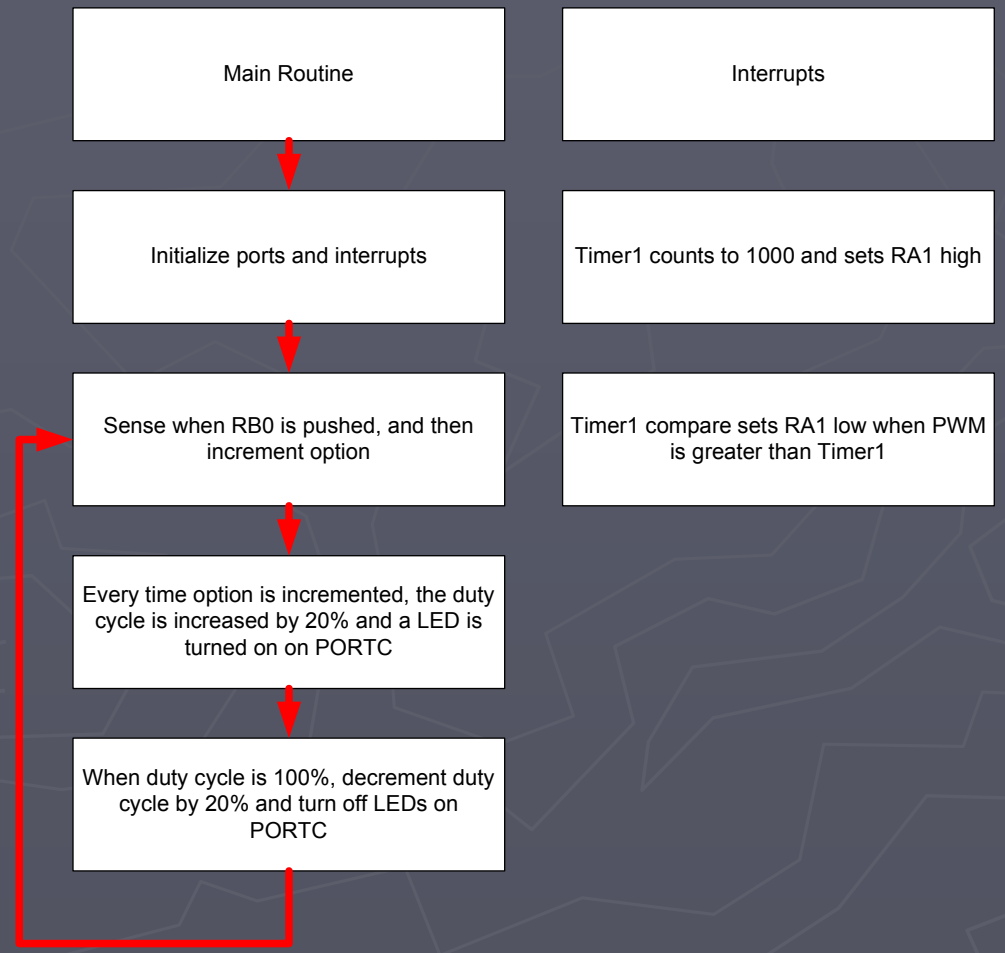
HV9910B Block Diagram



HV9910 Schematic

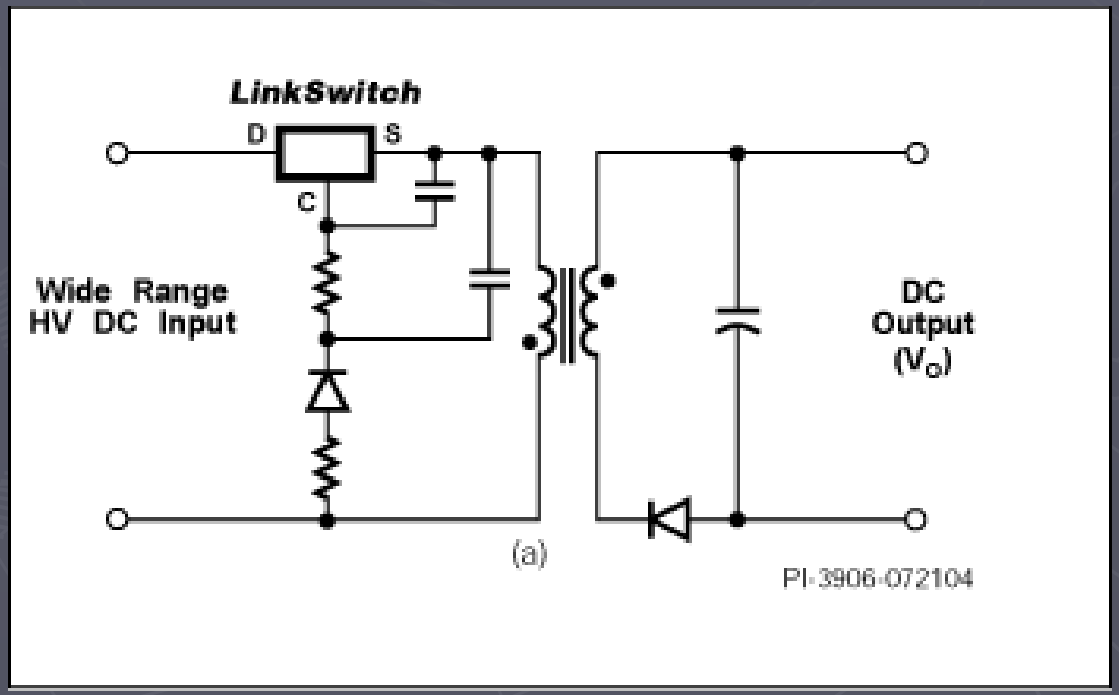


PIC Microcontroller



LNK500 IC

- Uses high switching frequency and a small transformer to convert 120VAC to 5VDC



Indicator Switch

- Receives power and transmits communication over Ethernet
- Utilizes 5 pins for indicator LEDs to display dimming levels
- Debounce Button transmits status back to pic to switch between dimming levels

LED String

- The string Is connected in series
- PCB has holes cut into it to allow thermal conduction
- Thermal Epoxy is used to adhere LEDs to heat sink

Enclosure

- Modified Existing 2 foot 2 bulb fluorescent fixture.

Lux and Lumens

- Used a Minolta Photo Meter to measure lux
- Lux: Unit based on lumens
- One lux is equal to one lumen per square meter
- The lux takes into account the area over which the luminous flux is spread

Lux Comparison

Illuminance	***Example***
10 lux	Candle at 1ft
50 lux	Family Living Room
80 lux	Hallway/Lavatory
400 lux	A brightly lit office
400 lux	Sunrise/Sunset
1,000 lux	Typical TV studio
32,000 lux	Sunlight on avg day (min)
100,000 lux	Sunlight on avg day (max)

Testing of Brightness

- 20 Luxeon K2 Emitter 65 Watt (1000mA)
  - 2 feet: 1040 lux
  - 6 feet: 150 lux
- General Electric 100 Watt Incandescent
  - 2 feet: 260 lux
  - 6 feet: 80 lux
- 2 Starcoat 4’ 32 Watt Fluorescent Tube (64 Watts)
  - 2 feet: 1040 lux
  - 6 feet: 260 lux

Lifespan of Lights

- A 100 Watt incandescent light costs $0.35 and lasts 1,000 hours
- A 32 Watt fluorescent tube costs $8.33 and lasts 5,000 hours
- Our 64 Watt LED string costs $93.40 and lasts 50,000 hours

Lumens per Watt

- Incandescent lights produce 17.4 Lumens per Watt
- Fluorescent tubes produce 60 Lumens per Watt
- Our LEDs produce 26.89 Lumens per Watt

Total Cost to Operate for 50,000 Hours

- Assuming electricity is $0.08 per kilowatt hour
  - Not including Maintenance Costs
- 100 Watt Incandescent light bulb costs $417.45
- 2 - 32 Watt Fluorescent tubes costs $438.60
- Our 65 Watt LED string costs $353.40

Problems Encountered and Lessons Learned

- Debounce switch was very sensitive.
  - We had to put a R-C filter at the pin
- VDD pin of HV9910 was not capable of driving a PIC
  - We had to use LNK500 to supply 5 volts for PIC
- External inductance of long wires, triggered the HV9910s internal comparators causing low output current
  - Strategic placement of components, and short traces on PCB minimized inductances

Problems Encountered and Lessons Learned

- The LED pads are fragile, and soldering LEDs to each other with 16Ga wire broke some of the LEDs
  - Using the PCB protected our LEDs more, and made it easier to adhere them to the heat sink
- Our inductor saturated, which limited our maximum current output
  - We had to increase the switching frequency of the oscillator
- Because there is no isolation between our circuit and the AC mains. Connecting earth ground to our circuit damaged various components

Budget

Date	Company	Quantity	Parts	Retail Per unit	Aquired Per Unit	Retail price	Aquired Price	Shipping	Aquired Price+ Shipping
11/27/2007	Fututre Electronics	20	Luxeon K2 Emmiter LEDS	$ 4.67	$ 4.67	$ 93.40	$ 93.40	$ -	$ 93.40
11/27/2007	Digi- Key	3	Inrush Current Limiter 50 Ohm 1.6A	$ 1.96	$ 1.96	$ 5.88	$ 5.88	$ -	$ 5.88
11/16/2007	Supertex	3	HV9910B Universal High Brightness LED Driver 16 pin	$ 1.15	$ 1.15	$ 3.45	$ 3.45	$ 5.00	$ 8.45
11/16/2007	Supertex	3	HV9910B Universal High Brightness LED Driver 8 pin	$ 0.94	$ 0.94	$ 2.82	$ 2.82	$ 5.00	$ 7.82
11/12/2007	Electronic precepts	2	Ther-O-Bond 1600 2 Part Epoxy	$ 12.56	$ 12.56	$ 25.12	$ 25.12	$ -	$ 25.12
11/9/2007	Digi-Key	1	Heat Sink	$ 27.00	$ 27.00	$ 27.00	$ 27.00	$ -	$ 27.00
11/9/2007	Digi-Key	1	Buck Convertor Parts - RLC Componets	$ 19.18	$ 19.18	$ 19.18	$ 19.18	$ -	$ 19.18
11/6/2007	Newark	15	IRF840 Power Switching Mosfets	$ 0.35	$ 0.35	$ 5.30	$ 5.30	$ -	$ 5.30
10/21/2007	Future Electronics	20	Luxeon K2 Emmiter LEDS	$ 4.65	$ 4.65	$ 93.06	$ 93.06	$ -	$ 93.06
10/15/2007	Digi-Key	10	RJ-45 Jacks	$ 2.70	$ 2.70	$ 27.00	$ 27.00	$ -	$ 27.00
10/15/2007	Jameco	1	3 debounce buttons, 10 22pf ceramic Capacitors	$ 1.78	$ 1.78	$ 1.78	$ 1.78	$ -	$ 1.78
9/28/2007	Supertex	3	HV9910B Universal High Brightness LED Driver	$ 0.94	$ 0.94	$ 2.82	$ 2.82	$ 10.00	$ 12.82
5/2/2007	Future Electronics	10	Luxeon K2 Emmiter LEDS	$ 3.45	$ 3.45	$ 34.50	$ 34.50	$ 9.00	$ 43.50
				$ -	$ -	$ -	$ -	$ -	$ -
Free									
4//2007	Advanced Thermal Solutions	1	LED Heat Sink	$ 28.00	$ -	$ 28.00	$ -	$ 15.00	$ 15.00
11/1/2007	Lowes	1	2 Ft Flourescent Light	$ 20.00	$ -	$ 20.00	$ -	$ -	$ -
		1	Dual Gang Switch Face Plate	$ 1.50	$ -	$ 1.50	$ -	$ -	$ -
		1	Dual Gang Wall Box	$ 2.16	$ -	$ 2.16	$ -	$ -	$ -
		1	Light Switch	$ 0.59	$ -	$ 0.59	$ -	$ -	$ -
11/9/2007		4	8 ft Pine 2"x4"	$ 1.68	$ -	$ 6.72	$ -	$ -	$ -
	Yuvarajan	1	LNK500 + RLC parts	$ 10.00		$ 10.00			
Totals				**$145.27**	**$ 81.34**	**$410.28**	**$341.31**	**$ 44.00**	**385.305**
				Under Budget					

Future Work

- Temperature Sensor
- Integrate Indicators with Switch to use only one gang wall box
- Use more efficient LEDs as they come on the market
- Using our PIC as a motion sensor, we could turn the LEDs off when there is no activity in the room

Summary

- We took 120 volts form the wall, rectified it and using the HV9910 controlled the current through the LED string
- To Vary the light Intensity of our string we used PWM with the PIC
- We used the LNK500 to supply the 5 volts needed to operate the PIC